Paternal Age as a Risk Factor for Low Birthweight

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Objectives. We examined associations between paternal age and low birthweight in the US urban population.

Methods. Using a population-based sample of 4621 births, we used multiple logistic regression analysis to estimate associations between paternal age and low birthweight, controlling for maternal age, other demographic factors, and the child's gender.

Results. When the child's gender and the mother's race/ethnicity, birthplace, parity, marital status, and health insurance type were controlled, teenaged fathers were 20% less likely and fathers older than 34 years were 90% more likely than fathers aged 20 to 34 years to have low-birthweight babies. The associations were significant when maternal age was also controlled. No racial/ethnic differences in associations between paternal age and low birthweight were found.

Conclusions. We identified paternal age as an independent risk factor for low birthweight in the US urban population, suggesting that more attention needs to be paid to paternal influences on birth outcomes and to the interactive effects of urban environments and individual risk factors on health. (*Am J Public Health.* 2006;96:862–866. doi:10.2105/AJPH.2005.066324)

Low birthweight is a leading cause of infant mortality in the United States and can lead to debilitating and costly long-term health problems for infants who survive. Low birthweight is associated with cerebral palsy, deafness, blindness, epilepsy, chronic lung disease, learning disabilities, and attention deficit disorder.[1,2] The annual cost of low birthweight in 1988 was estimated at $5.5 to $6 billion[3]; an updated estimate probably would be much higher.

Generally, teenaged mothers and older mothers are at higher risk of delivering low-birthweight babies than mothers aged 20 to 34 years.[4] However, for Black or disadvantaged mothers, the risk of low birthweight has been found to increase with age even at the low end of the age distribution. This phenomenon has been attributed to "weathering"—a premature deterioration of health among individuals who are exposed to harsh living conditions.[5,6]

Paternal age has received less attention than maternal age in studies of low birthweight, even though advanced paternal age has been linked to sperm abnormalities and gene mutations,[7–9] preeclampsia,[10] miscarriage,[11] and some birth defects.[12–15] One recent study found a positive association between paternal age and preterm birth in Denmark.[16] The few previous studies of the association between paternal age and birthweight in the United States or Canada found no evidence of a detrimental effect of increased paternal age.[17–20] However, those studies focused on national, state, or low-risk populations. None focused on urban or disadvantaged populations at high risk of weathering.[21] Additionally, they relied on birth certificate data, which in the United States have high rates of missing data on paternal age.[4]

This is the first study to investigate the association between paternal age and low birthweight in an urban population. Using a national sample of urban births between 1998 and 2000, we compared associations between paternal age and low birthweight with associations between maternal age and low birthweight. We also explored racial/ethnic differences in the associations between low birthweight and parents' ages.

METHODS

Sample

As part of a national longitudinal birth cohort study, births were randomly selected from each of 75 hospitals in 20 US cities with populations greater than 200 000. The field periods for the different hospitals were staggered between 1998 and 2000. Births to unmarried women were oversampled. While still in the hospital after giving birth, mothers were approached by a professional survey interviewer and screened for eligibility. If eligible, they were asked to participate in a national survey about the conditions and capabilities of new parents, their relationships, and their children's well-being. A mother was eligible for the study if both she and the baby's father were at least 18 years old or, if they were minors, the hospital allowed recruitment of minors into the study; if she was able to complete the interview in either English or Spanish; if the father of the newborn was living; and if they were not planning to place the child for adoption. The fathers were also asked to participate in an interview. Informed consent was obtained. A total of 4898 mothers (86% of those eligible) were interviewed between the spring of 1998 and the fall of 2000; 78% of the fathers were interviewed.[22]

Of the 4898 mothers who agreed to participate, 4621 were included in the analysis; 95 were excluded because the birth was a multiple birth, 27 were excluded because of missing birthweight, 74 were excluded because of missing maternal or paternal age, and 81 were excluded because of missing data on other analysis variables.

Characteristics

Maternal age, obtained from the mother's report, was categorized as younger than 20 years, 20 to 34 years (the reference group), or 35 years and older to capture the nonlinear association between age and low birthweight described earlier. Paternal age was obtained from the mother's report and categorized in the same way, because there was little existing work in this area to guide us (we assessed the sensitivity of the results to alternative age categorizations; see the "Results" section). Maternal reports of paternal age were validated against self-reports of fathers

who completed interviews. The correlation of paternal ages from the 2 sources was 0.98.

Low birthweight was defined as less than 2500 g. Birthweights were obtained from mothers' reports and converted from pounds and ounces to grams. These were validated against birthweights recorded by hospital staff for a subset of 2305 births for which medical records were reviewed. The correlation of birthweights from the 2 sources was 0.98. The rate of low birthweight in this sample from 20 large US cities (10.1%) is slightly higher than the rate found for the 100 largest US cities and their suburbs in 2000 (8.9%).[23]

Maternal demographic characteristics, health insurance status, and the child's gender were obtained from maternal reports. Maternal race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, or other. For maternal birthplace, we distinguished between US-born and foreign-born mothers. For parity, we distinguished between first births and births to women who had previously given birth to other children. Marital status referred to whether the mother was married to the baby's father at the time of the birth. Mother's health insurance status was used instead of education as a control for socioeconomic status because of the high correlation of education and very young age. Health insurance status was categorized as private, Medicaid (in California, Medi-Cal), or other (other government, charity, uninsured, or self-pay).

TABLE 1—Distribution (No. [%]) of Maternal Characteristics and Child's Gender, by Paternal Age Group: Sample of Births in 20 US Cities With Populations Greater Than 200 000, 1998–2000

	Paternal Age			
	<20 y (n = 384)	20–34 y (n = 3382)	>34 y (n = 855)	All (N = 4621)
Mother's age, y**				
<20	271 (71)	531 (16)	8 (1)	810 (18)
20–34	113 (29)	2759 (82)	508 (59)	3380 (73)
>34	0 (0)	92 (3)	339 (40)	431 (9)
Mother's race/ethnicity**				
Non-Hispanic White	49 (13)	677 (20)	249 (29)	975 (21)
Non-Hispanic Black	225 (59)	1568 (46)	396 (46)	2189 (47)
Hispanic	103 (27)	1004 (30)	163 (19)	1270 (27)
Other	7 (2)	133 (4)	47 (6)	187 (4)
Mother US-born**				
Yes	361 (94)	2815 (83)	662 (77)	3838 (83)
No	23 (6)	567 (17)	193 (23)	783 (17)
Mother had had other children**				
Yes	127 (33)	2056 (61)	674 (79)	2857 (62)
No	257 (67)	1326 (39)	181 (21)	1764 (38)
Mother and father married**				
Yes	5 (1)	779 (23)	350 (41)	1134 (25)
No	379 (99)	2603 (77)	505 (59)	3487 (75)
Mother's health insurance status at time of birth**				
Private insurance	62 (16)	1023 (30)	400 (47)	1485 (32)
Medicaid	310 (81)	2256 (67)	426 (50)	2992 (65)
Other[a]	12 (3)	103 (3)	29 (3)	144 (3)
Child's gender*				
Boy	228 (59)	1776 (53)	436 (51)	2440 (53)
Girl	156 (41)	1606 (47)	419 (49)	2181 (47)

[a]Includes other government insurance, charity, no insurance, and self-pay.
*P < .05; **P < .001 for differences across paternal age groups, on the basis of χ^2 tests for equal distributions.

Analysis

We used multiple logistic regression to estimate the associations of both maternal and paternal age with low birthweight. Stata/SE version 8 software (StataCorp LP, College Station, Tex) was used to conduct all statistical analyses. We calculated odds ratios (ORs) and 95% confidence intervals (CIs; 2-tailed) for 3 models. The first model examined the association between mother's age and low birthweight, with adjustment for maternal demographic characteristics and the child's gender. The second model examined the association between father's age and low birthweight, with adjustment for maternal demographic characteristics (other than age) and the child's gender. The last model included maternal and paternal age in addition to the other maternal demographic variables and the child's gender. Model 3 therefore indicated the association between father's age and low birthweight, with mother's age and other covariates controlled. Because associations between maternal age and low birthweight differ by race, we also calculated odds ratios and confidence intervals separately for non-Hispanic Whites and non-Hispanic Blacks, as well as for Hispanic mothers, for whom less is known about age patterns in low birthweight.

RESULTS

The distributions of maternal and paternal ages are shown in Table 1. Eighteen percent of the mothers and 8% of the fathers were aged younger than 20 years at the time of their child's birth, 73% of the mothers and fathers were 20 to 34 years old, and 9% of the mothers and 19% of the fathers were aged 35 years or older. Almost three quarters (73%) of the fathers were in the same age group as their baby's mother. The age distributions of non-Hispanic Whites, non-Hispanic Blacks, and Hispanics were very similar to those of the full sample (figures for mothers not shown).

The paternal age groups differed with regard to all covariates. Increased paternal age was significantly associated with mother's age, race/ethnicity, parity, marital status, birthplace,

TABLE 2—Odds Ratios (With 95% Confidence Intervals [CIs]) From Multiple Logistic Regression Analysis of Associations Between Parents' Age and Low Birthweight and Between Other Covariates and Low Birthweight: Sample of Births in 20 US Cities With Populations Greater Than 200 000, 1998–2000 (N = 4621)

	Model 1 (95% CI)	Model 2 (95% CI)	Model 3 (95% CI)
Mother's age, y			
<20	1.0 (0.8, 1.3)	. . .	1.2 (0.9, 1.6)
>34	2.1† (1.5, 2.8)	. . .	1.5** (1.0, 2.1)
Father's age, y			
<20	. . .	0.8 (0.5, 1.1)	0.7* (0.5, 1.0)
>34	. . .	1.9† (1.5, 2.4)	1.7† (1.3, 2.2)
Other covariates			
Mother non-Hispanic Black	1.4** (1.1, 1.9)	1.4** (1.1, 1.9)	1.4** (1.1, 1.9)
Mother Hispanic	0.7** (0.5, 1.0)	0.7* (0.5, 1.0)	0.7* (0.5, 1.0)
Mother other race/ethnicity	1.1 (0.6, 2.0)	1.1 (0.6, 2.0)	1.1 (0.6, 2.0)
Mother US-born	1.6** (1.1, 2.3)	1.7*** (1.2, 2.5)	1.7*** (1.2, 2.5)
Mother had had other children	0.9 (0.7, 1.1)	0.8** (0.6, 1.0)	0.8* (0.7, 1.0)
Mother and father married	0.7** (0.5, , 1.0)	0.7** (0.5, 1.0)	0.7** (0.5, 1.0)
Mother on Medicaid	2.0† (1.6, 2.7)	2.1† (1.6, 2.7)	2.1† (1.6, 2.8)
Mother on other non-private health insurance	2.0** (1.1, 3.5)	2.0** (1.1, 3.4)	2.0** (1.1, 3.5)
Child is male	0.8* (0.7, 1.0)	0.8* (0.7, 1.0)	0.8* (0.7, 1.0)

Note. The reference age group was 20–34 years.
*P<.10; **P<.05; ***P<.01; †P<.001.

and health insurance status (P<.001 in each case) and with the child's gender (P<.05). The directions of the associations were largely as expected: The likelihood that the mother was US-born, married, had other children, and had private health insurance increased with paternal age. Partners of non-Hispanic White mothers were the most likely, and partners of Hispanic mothers were the least likely, to be older than 34 years.

After adjusting for maternal race/ethnicity, birthplace, parity, marital status, health insurance status, and the child's gender, we found that mothers aged 35 years and older were more likely than mothers aged 20 to 34 years to have low-birthweight babies (Table 2, model 1; OR=2.1, 95% CI=1.5, 2.8; P<.001). The association was reduced by half when we adjusted for paternal age (model 3; OR=1.5, 95% CI=1.0, 2.1; P<.05). In this sample, mothers aged younger than 20 years were neither significantly more nor significantly less likely than mothers aged 20 to 34 years to have low-birthweight babies.

The associations between paternal age and low birthweight were as strong as those between maternal age and low birthweight. When we controlled only for the mother's demographic characteristics (other than age) and the child's gender, we found that teenaged fathers were less likely than fathers aged 20 to 34 years (the reference group) to have low-birthweight babies, although the association was not statistically significant (Table 2, model 2). When we adjusted for the mother's age in addition to the other covariates, we found that teenaged fathers were 70% as likely as fathers aged 20 to 34 years to have low-birthweight babies (Table 2, model 3; OR=0.7, 95% CI= 0.5, 1.0; P<.10). Fathers aged 35 years or older were 1.9 times as likely (P<.001) as fathers aged 20 to 34 years to have low-birthweight babies, after adjustment for maternal demographic characteristics (other than age) and the child's gender (Table 2, model 2). This association was only slightly reduced when we adjusted for maternal age (Table 2, model 3).

The directions of the associations between the other covariates and low birthweight were similar to those described in previous research.[2] Non-Hispanic Black mothers were more likely than non-Hispanic White mothers to deliver low-birthweight babies. Hispanic mothers were less likely than their non-Hispanic White counterparts to deliver low-birthweight babies. Being born in the United States and being poor (having Medicaid coverage for the birth) were risk factors for low birthweight; having had previous children, being married, and having a male child decreased the likelihood of low birthweight.

The patterns were generally similar across racial/ethnic groups, although the small sample sizes (particularly for non-Hispanic Whites) made statistically significant results less likely (Table 3). When we controlled for maternal demographic characteristics, the child's gender, and paternal age, we found that maternal age older than 34 years was a significant risk factor for low birthweight among non-Hispanic Blacks and Hispanics. For each racial/ethnic subgroup, the association between paternal age older than 34 years and low birthweight was virtually identical to that for the full sample (Table 2, model 3; OR=1.7, 95% CI=1.3, 2.2). The associations between paternal age younger than 20 years and low birthweight, though not significant for any racial/ethnic subgroup, were negative in all models.

Because there was little previous research to guide us in the specification of paternal age categories, we assessed the sensitivity of the results to a number of different age breakdowns. Alternative sets of models were estimated with (1) 3 categories for paternal age (<20, 20–34, ≥35 years), with a continuous characterization of maternal age (the models included terms for age in years and age squared); (2) 4 age categories for both parents (<18, 18–21, 22–34, ≥35 years); (3) 5 age categories for both parents (<20, 20–24, 25–29, 30–34, ≥35 years); and (4) the 5 age categories for fathers, with the continuous characterization of maternal age. Regardless of age breakdown or reference group, fathers aged 35 years or older were at greatest risk of having low-birthweight babies, after mother's age and other demographic characteristics and the child's gender were controlled. The odds ratios for low birthweight among fathers aged 35 years or older ranged from 1.3 to 1.8.

We calculated odds ratios and confidence intervals, separately, (1) for parents aged at least 18 years, (2) with adjustment for

TABLE 3—Odds Ratios (With 95% Confidence Intervals [CIs]) From Multiple Logistic Regression Analysis of Associations Between Parents' Ages and Low Birthweight, by Race/Ethnicity of Mother: Sample of Births in 20 US Cities With Populations Greater Than 200 000, 1998–2000 (N = 4621)

	Non-Hispanic White (n = 975) (95% CI)	Non-Hispanic Black (n = 2189) (95% CI)	Hispanic (n = 1270) (95% CI)
Mother's age, y			
< 20	1.4 (0.7, 2.7)	1.1 (0.8, 1.6)	1.3 (0.6, 2.5)
> 34	0.8 (0.3, 2.0)	1.6** (1.0, 2.6)	2.4** (1.1, 5.3)
Father's age, y			
< 20	0.5 (0.1, 1.6)	0.9 (0.6, 1.4)	0.5 (0.2, 1.5)
> 34	1.7 (0.9, 3.3)	1.7*** (1.2, 2.4)	1.8* (0.9, 3.5)

Note. Data not shown for mothers whose race/ethnicity was classified as "other" (n = 187). In all models, the child's gender and the mother's birthplace, parity, marital status, and health insurance status were controlled. The reference age group was 20–34 years.
*P < .10; **P < .05; ***P < .01.

maternal education in addition to health insurance status and the other measures, and (3) for full-term (at least 37 weeks' gestation) births, using the subsample of 2305 births for which medical records were available. The findings were consistent across specifications, indicating that the associations we found for teenaged parents apply to 18 and 19 year-olds but not necessarily to parents aged younger than 18 years, who were underrepresented in our sample; the associations overall were not driven by the measure of socioeconomic status we used; and paternal age is associated with low birthweight, even among births that are not preterm, suggesting that paternal age may reduce birthweight through retarded fetal growth. (Results from the supplementary analyses are available from the authors.)

DISCUSSION

Using a population-based urban sample and adjusting for maternal age and other risk factors, we found that increased paternal age is positively associated with the probability of low birthweight. The paternal age associations are as large as those of maternal age and are substantial compared with those of other known risk factors for low birthweight, such as race, which have received substantial public health attention. It is important to note, however, that comparisons of regression estimates do not provide information on the relative risks attributable to different factors, which depend not only on effect sizes but also on the prevalence of the different risk factors in the population.

Geronimus found a paradoxical birth outcome advantage among Black teenaged mothers relative to older Black mothers.[5,6] She suggested that this finding may reflect a more rapid deterioration in health with age among Black women than among White women, owing to Black women's greater cumulative exposure to harsh living conditions. She coined the term "weathering" to describe this phenomenon. She also found that residents of persistently impoverished urban areas, particularly Black men, are at extremely high risk for morbidity at early ages and suggested that weathering, caused by cumulative exposure to hazards in residential and work environments or to chronic stress, is a potential explanation.[21]

Our finding that paternal age is independently and positively associated with the probability of low birthweight suggests a possible paternal weathering phenomenon. Several previous studies found detrimental effects of paternal age on infant outcomes, but they did not investigate associations between paternal age and birthweight.[12–15] The few studies that specifically looked at paternal age and birthweight[17–20] did not find adverse effects of increased age, but those studies used vital statistics data and focused on low-risk samples. In 2000, paternal age was not reported for 24% of births to all women aged younger than 25 years and for 39% of all births to unmarried women in the United States.[4] Two of the studies[17,19] focused on births to married women for this reason, and therefore underrepresented the urban poor. The other 2 studies were based on statewide samples of births in North Dakota[18] and North Carolina,[20] states in which 0% and 20% of the population, respectively, resides in cities of more than 100 000 people (authors' computations from 2000 US census data[24,25]). It is therefore possible that these studies did not detect paternal age effects because they focused on low-risk populations. Ours is the first study to examine the association between paternal age and low birthweight in an urban population. The absence of associations in low-risk populations and the presence of a positive association between paternal age and low birthweight in our urban sample are consistent with a paternal weathering effect.

A number of potential mechanisms could underlie the association between paternal age and low birthweight. Some involve direct biological effects of male aging, which may be hastened by exposure to harsh living conditions. Age-associated sperm abnormalities or chromosomal mutations may affect fetal growth. For example, increases with age in the number of paternal germ cell divisions have been hypothesized to increase the risk for spontaneous mutation, which may lead to genetically based fetal developmental disorders.[26,27] Some mutations may confer a survival benefit to sperm within the cellular environment of the testes, as has been found in the case of the FGFR2 mutation associated with Apert syndrome.[8]

Paternal genes may affect placental growth, as has been found in mice.[28] It is also possible that the sustained nature of spermatogenesis is associated with age-related vulnerability to compromised DNA-protective mechanisms[29] or environmental exposures that impede fetal development. Whether such vulnerabilities occur at earlier ages among disadvantaged (potentially weathered) fathers is an empirical question that has not been explored. Paternal substance use over a prolonged period of time may adversely affect sperm. Previous studies have found associations between paternal smoking[12,30] and alcohol use[12,31] and adverse reproductive outcomes, although little is

known about potential mechanisms that might underlie these associations.

Paternal aging may also affect low birthweight indirectly, through its effects, biological or social, on the mother's health. One study found an association between paternal age and preeclampsia,[10] a known risk factor for low birthweight. Potential social mechanisms may involve the dynamics of the parents' relationship. For example, domestic violence or lack of financial or emotional support could affect mothers' physical, emotional, and reproductive health, possibly through increased stress, involvement in substance use, or lack of medical care. The extent to which paternal age or age differences between the parents is associated with such risk factors has been little explored.

As far as we know, this was the first study to document a positive association between paternal age and low birthweight in the United States. It should be replicated and the association further explored. Our study was subject to some limitations. The sample underrepresented parents aged younger than 18 years. Sample sizes precluded us from testing for interaction effects between more refined age and racial/ethnic categories. Health insurance status is an imperfect proxy for socioeconomic status. Finally, although we have established associations, we cannot investigate the underlying causal mechanisms or rule out the possibility that the associations are confounded by unmeasured factors. The absence of measures of parents' cumulative exposure to harsh living conditions precluded us from directly testing the paternal weathering hypothesis.

Our finding that paternal age is an independent risk factor for low birthweight in an urban population suggests that more attention needs to be paid to paternal influences on birth outcomes and, more generally, to the interactive effects of urban environments and individual risk factors on health. ■

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Contributors

Both authors contributed to the design of the study, the analysis and interpretation of the data, and the writing and revision of the article.

Human Participant Protection

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